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Final Technical Report

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"The Origin of Maghemite on Mars"

by

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As originally proposed, two alternative explanations for the magnetic properties of the Martian surface material were to be explored:

(1) That all surface particles were coated with a thin layer of red magnetic ferric oxide or hydroxide (e.g. maghemite) precipitated from solution.

(2) That the surface particles were composed primarily of smectite clay (nontronite) pigmented throughout by a red magnetic phase. Because of budget cuts, we concentrated our efforts on the second hypothesis, with the following results:

The thermal treatment of nontronite in air, for long periods at $700^{\circ}C$ or short periods at $900^{\circ}C$, results in destruction of the nontronite structure, a distinct reddening in color, and a spectacular increase in magnetic susceptibility and saturation magnetization (up to 4.4 Am^2/kg). Magnetic property measurements suggest that the magnetism is due to the presence of ultrafine particles of α or γ Fe_2O_3; the precise identity has not yet been resolved. The highly magnetic thermally treated nontronite is amorphous to x-rays consistent with an ultrafine grain size. Prolonged heating results in the growth of α Fe_2O_3, as suggested by x-ray, IR reflectance, and magnetic measurements. Reflectivity spectra of a sample heated for 1 hour at $900^{\circ}C$ indicates, in addition to α Fe_2O_3, the presence of an opaque, magnetite-like phase. Given the composition of the starting material, and the experimental conditions, the presence of Fe_3O_4 is unlikely; the cause of this opacity is as yet unknown. Thermally treated nontronite has chemical, color and magnetic properties akin to those found by Viking on Mars. These results favor an origin for the fine grained Martian surface material by repeated impacts into an Fe-rich smectite-charged regolith, the smectite having resulted from hydrothermal alteration of volcanic or impact generated glass, the magnetic phase having resulted from the pressure or thermally shocked nontronite.

Publications include:

Moskowitz, B. M. and Hargraves, R. B. (1982), Magnetic changes accompanying the thermal decomposition of nontronite (in air) and its relevance to Martian mineralogy, J. Geophys. Res., 87, 10115-10128.

Moskowitz, B. M. and Hargraves, R. B. (1982), Magnetic properties of heat-treated nontronite and its relevance to Martian mineralogy, EOS, 63, 310.

Egan, W. G., Hargraves, R. B. and Pollack, J. B. (1982), Probable Existence of ferric oxide compounds in Martian soil, EOS, 63, 365.